



**DOGO Warn Levels:**  
**You've got them**  
**Let's use them**

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**Data version 7**

# Warn Levels: A Quick Guide

# WL: Usage Definition

A number for each OCO-2 sounding: 0 to 19

Estimates sounding complication / contamination  
(lower is better)

WL 0-5 is least confounded

WL 6-15 useful but increasingly confounded

WL 16-19 is likely and increasingly useless

**YOU DECIDE WHERE TO DRAW YOUR LINE**  
WL's make it easy to do so

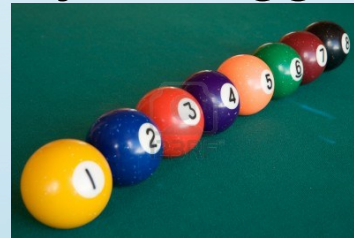
# That's what the Quality Flag is for?

**NO!**

## Quality Flag isn't enough

- $QF := WL \leq 15$  & outlier\_filter & outcome  $\leq 2$
- Still have  $0 \leq WL \leq 15$  to help make your custom filter
- All passed soundings still continuum of confounding forces

WL's order data rather than just flagging



## Using Only Quality Flag ~ Dark Side

Faster, Easier

Less Powerful

Can lead to Pain and Suffering



# How to use WL's power

## Step 1: Decide what to filter / keep



### Require:

popcorn clouds  
spot studies  
N < 50k

### Reject:

wild XCO<sub>2</sub>  
cloud banks  
thick aerosols



### Require:

clear skies  
coastlines  
globe coverage

### Reject:

any XCO<sub>2</sub>  
complexities



### Require:

globe coverage  
max soundings

### Reject:

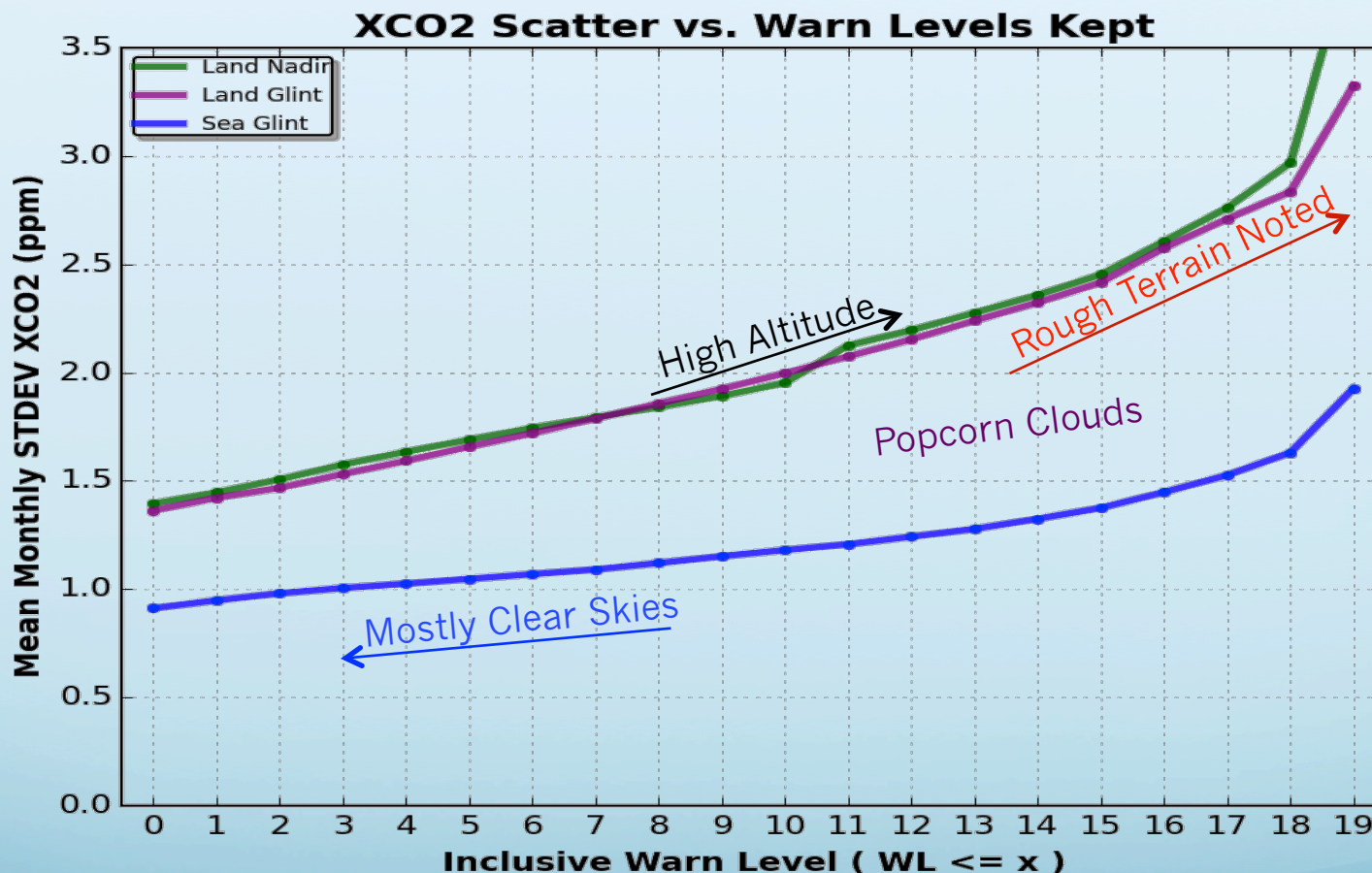
Rough terrain

Only you can answer this



# How to use WL's power

## Step 2: Sweep WL ranges

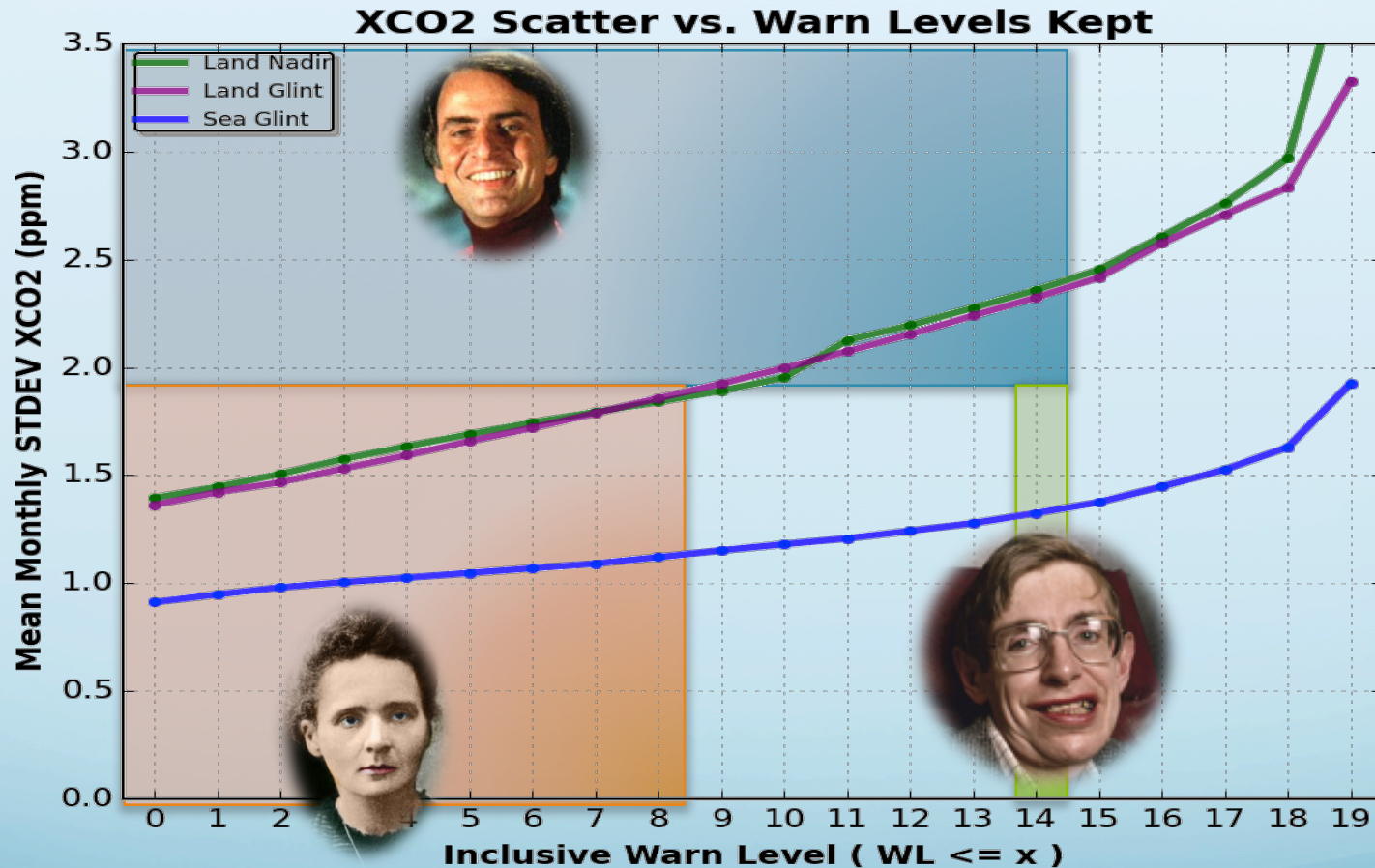


Plot things you care about vs. WL  
Explore ranges for useful data



# How to use WL's power

## Step 3: Fix WL range when satisfied



Each analysis derives its own WL range

# Simple to Communicate

## A single number does heavy lifting



### Cloud study

**WL=14**

Max. cloud shadows  
Min. other effects  
Small N obtained



### Coastline Study

**WL<8**

Strongly reduce aerosols  
Global coverage  
Coastal coverage



### Flux Inversion

**WL<14**

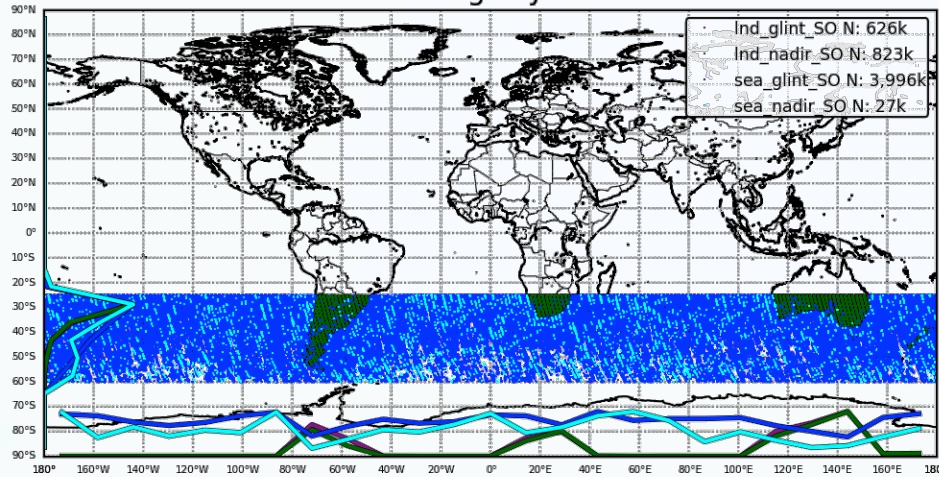
Global Coverage  
Avoid Clouds  
Avoid rough terrain

Decide on well-founded filtration in an  
afternoon rather than days

# What Metrics Derive WL's?

# Surrogate Truth

Soundings by Mode



## Southern Hemisphere

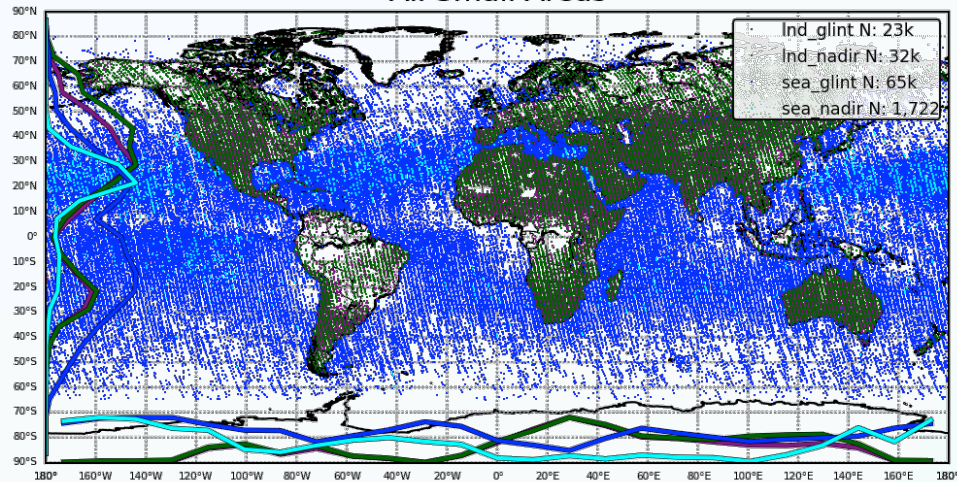
### Pros:

- Large-scale confounders  
airmass, seasonal, solar zenith...
- Small-scale confounders  
Surface parameters, snr, etc.

### Cons:

- Real latitude  $\text{XCO}_2$  gradient
- Not much land
- $\text{XCO}_2$  isn't truly constant in time

All Small Areas



## Small Areas

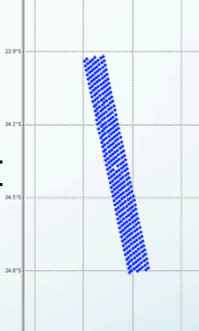
### Pros:

- $\text{XCO}_2$  really is nearly constant
- Global coverage, not just SH
- HD Small-scale confounders  
Surface parameters, snr, etc.

### Cons:

- Large-scale confounders  
inaccessible
- Small(ish) N statistics ~100-300

Small Area 2511 Num: 381



Span < 100km  
N > 100  
Contiguous

# Data Ordering Genetic Optimization (DOGO)

- Desire to minimize STD in low-XCO<sub>2</sub> variation regions (SH / SA)
- Use Genetic Algorithm to explore effect of all possible filters
- Filters can be based on any number of features (out of hundreds)
- End up with list of “most powerful” features
- Also thresholds for the chosen features that define WL's



Winner JPL Software of the Year  
Runner-Up NASA Software of the Year

OCO-2  
Training Set



## Chosen Features

Aerosol\_total\_aod  
Surface\_pressure\_delta  
Roughness  
Rel\_resid\_mean2\_SCO<sub>2</sub>  
CO<sub>2</sub>\_vertical\_gradient\_delta

## WL Thresholds

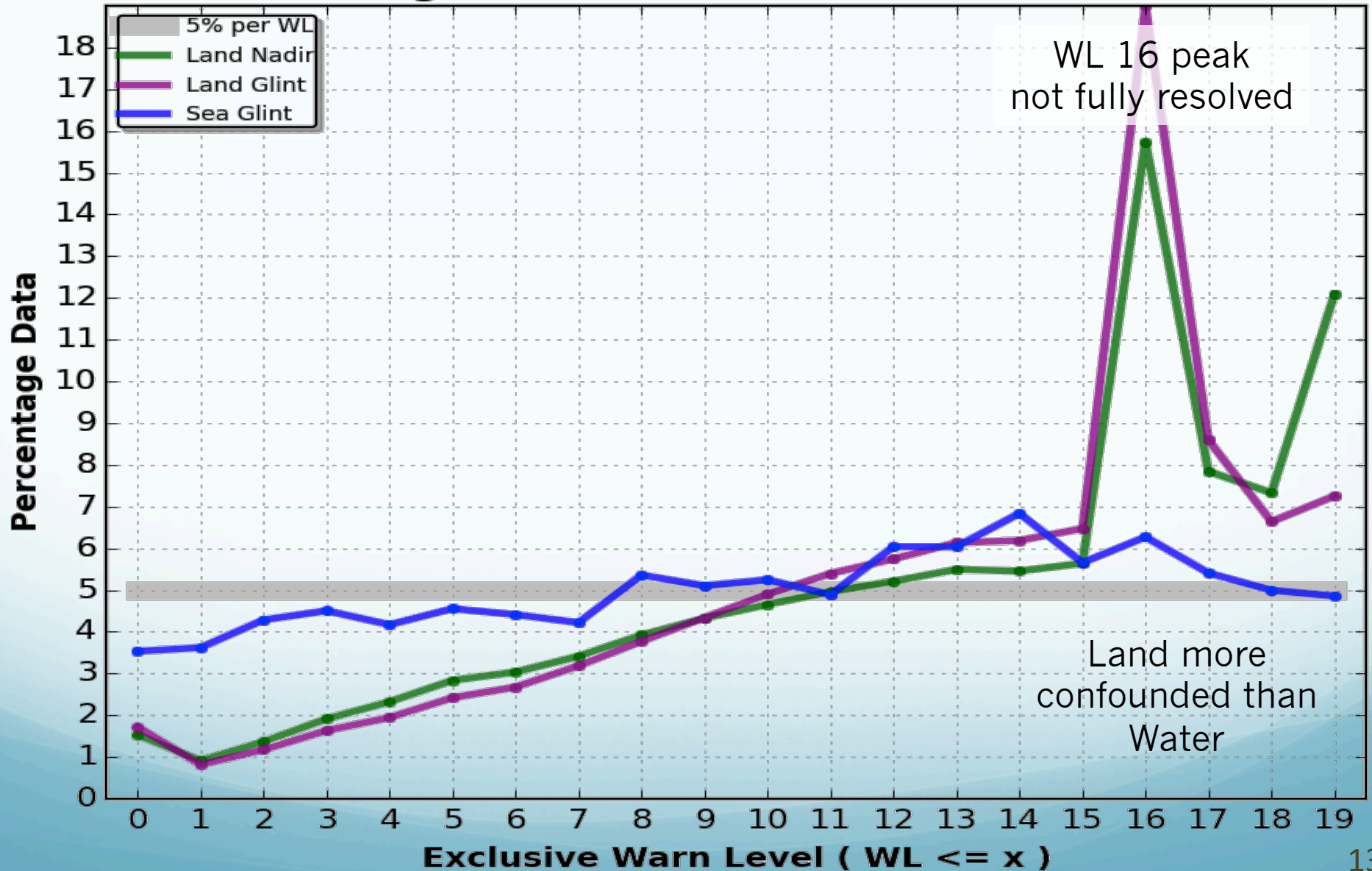
1	0.046	1.4E-05	-6.6E-06	-1.0E-05
2	0.051	1.3E-05	-6.0E-06	-1.0E-05
3	0.056	1.3E-05	-5.4E-06	-1.1E-05
4	0.061	1.2E-05	-4.8E-06	-1.1E-05
5	0.065	1.1E-05	-4.2E-06	-1.2E-05
6	0.070	1.1E-05	-3.5E-06	-1.2E-05
7	0.075	1.0E-05	-2.9E-06	-1.3E-05
8	0.080	9.5E-06	-2.2E-06	-1.3E-05

# Warn Levels: Effects & Distributions

Sep 2014 – Sep 2015

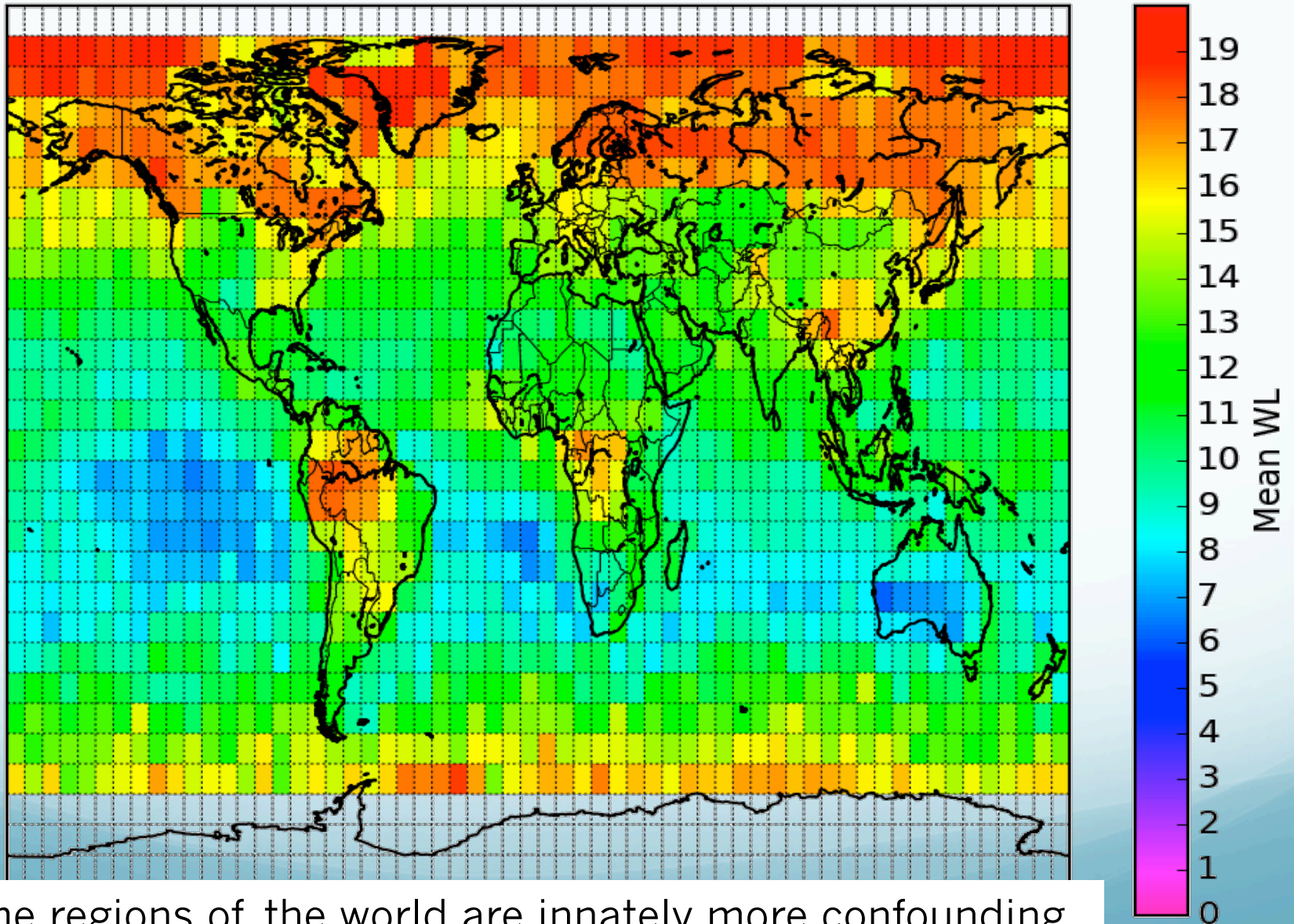
# Warn Level Distribution

Percentage Data at each Exclusive Warn Level



# Spatial WL Coverage

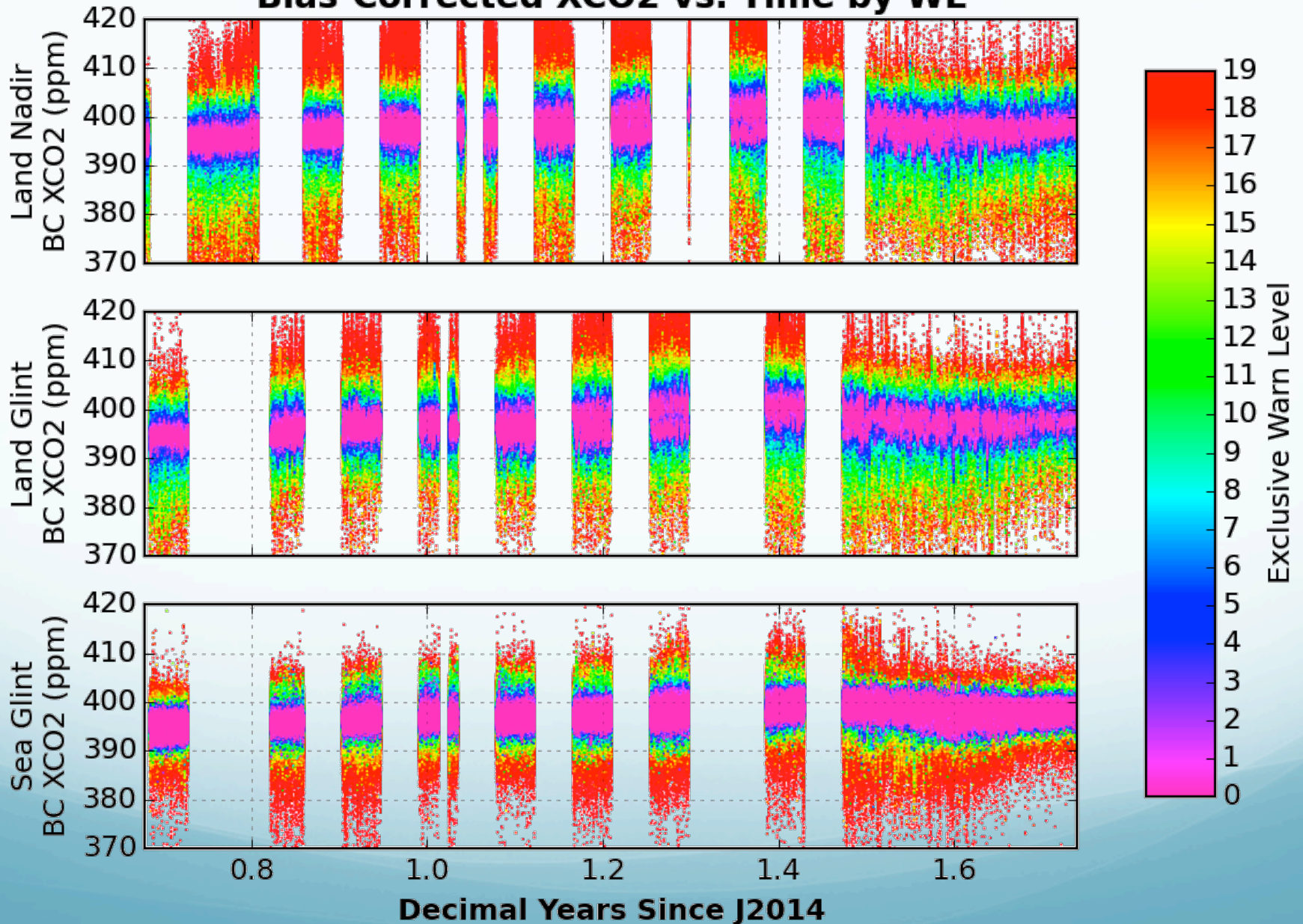
Mean WL



Some regions of the world are innately more confounding

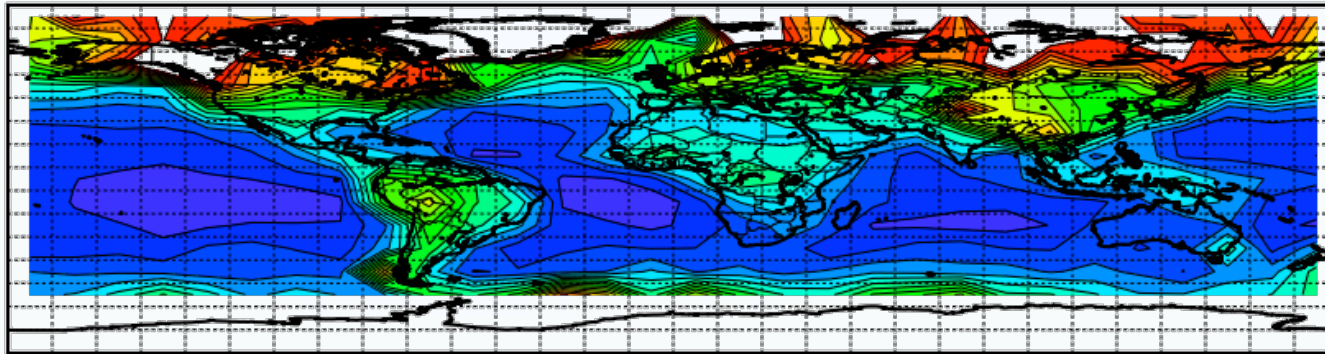
# Temporal Coverage

**Bias-Corrected XCO<sub>2</sub> vs. Time by WL**

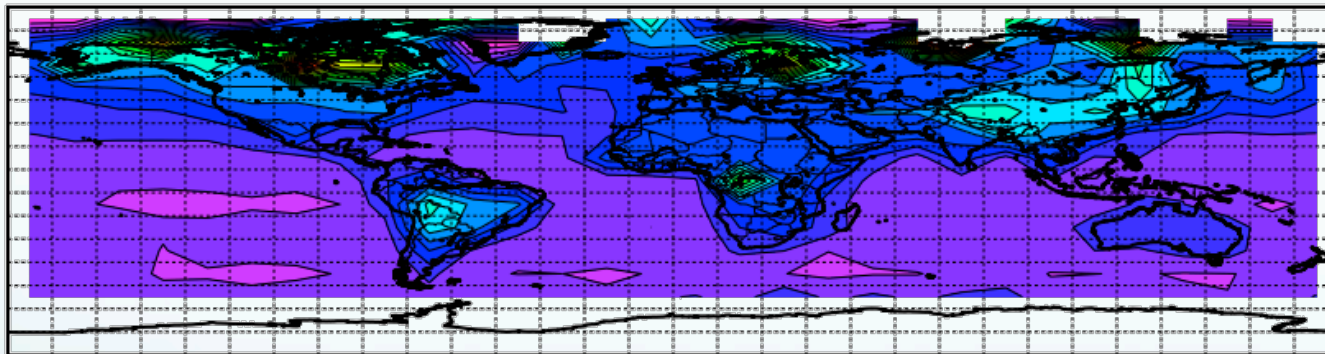


# STDEV( $x_{CO_2}$ - bin monthly mean)

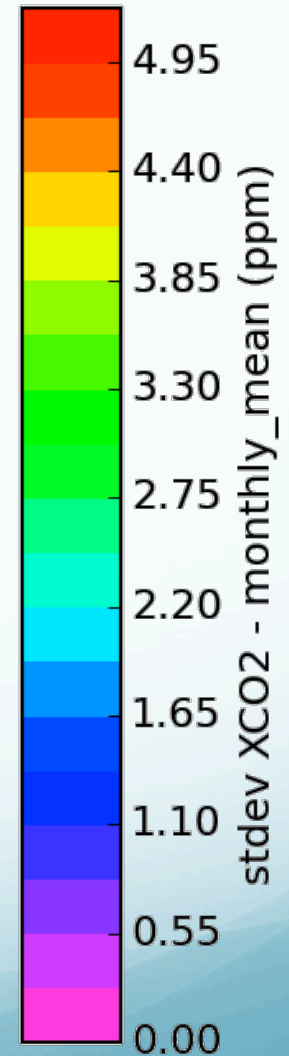
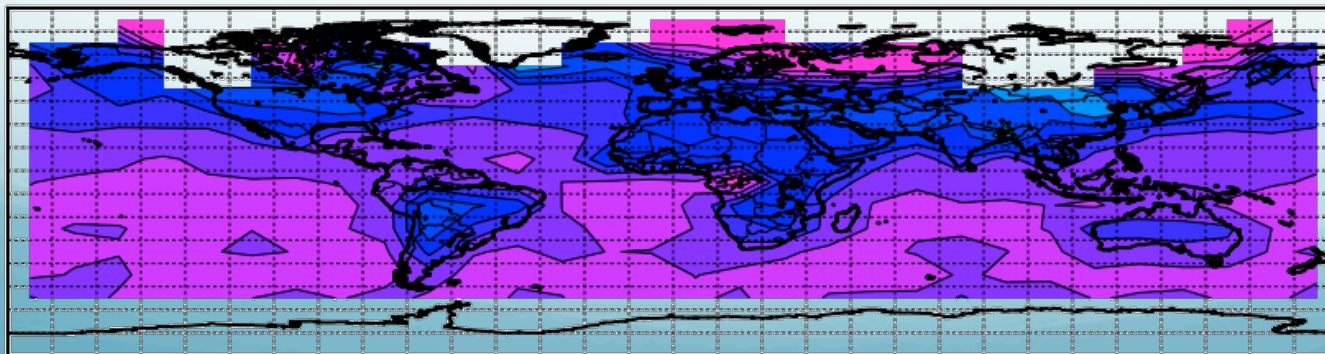
WL  $\leq$  19



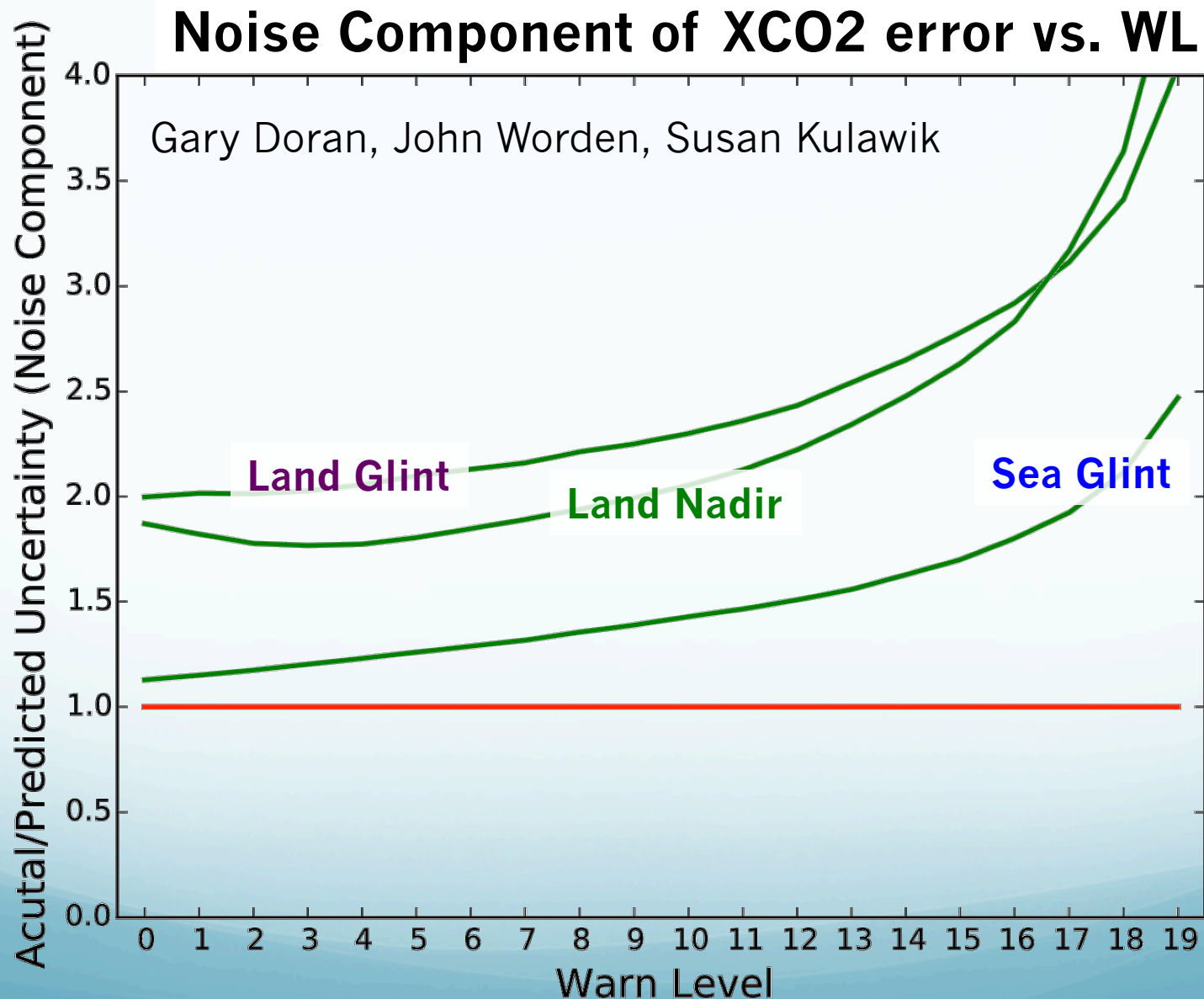
WL  $\leq$  10



WL  $\leq$  5

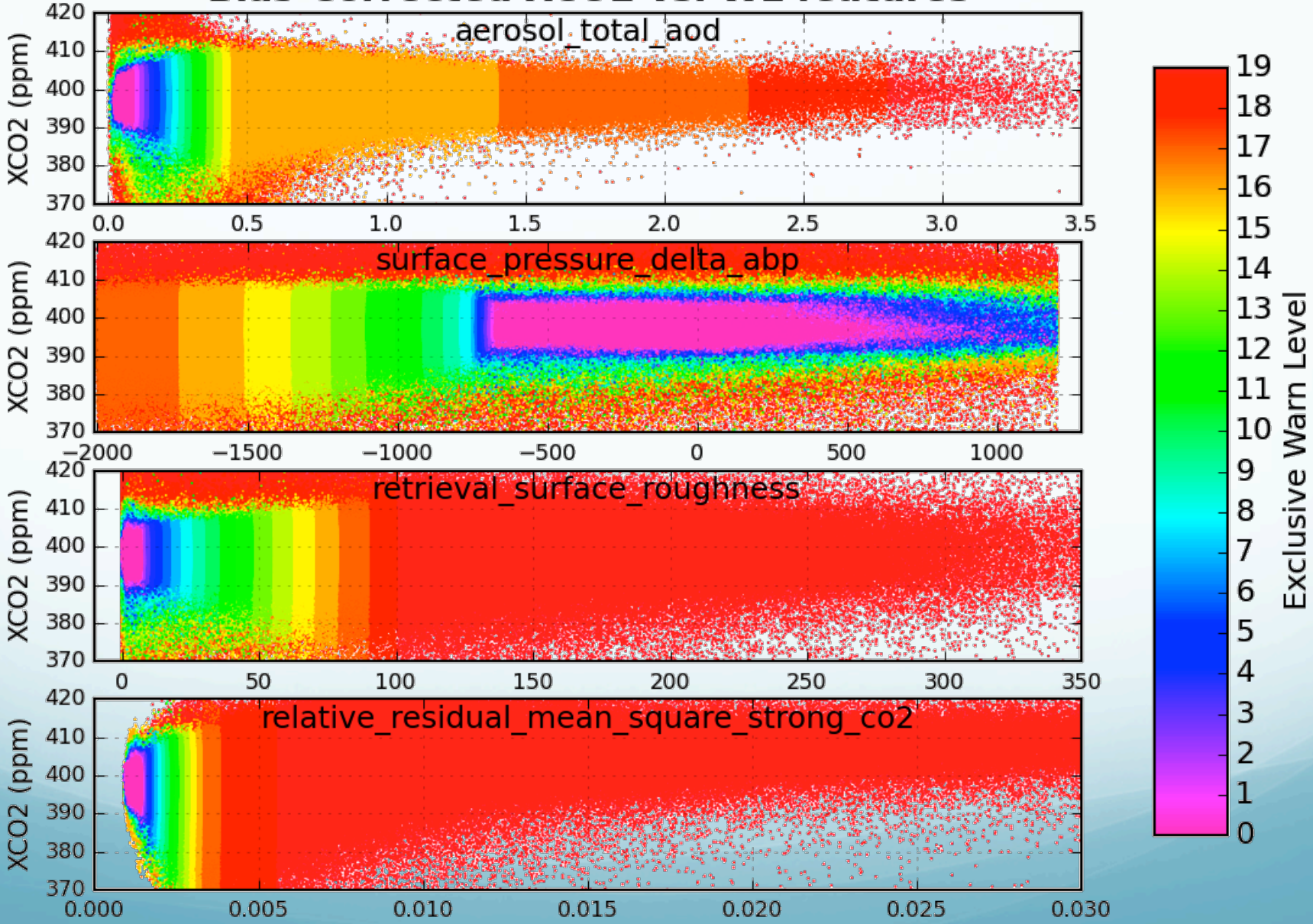


# WL vs. XCO2 Uncertainty

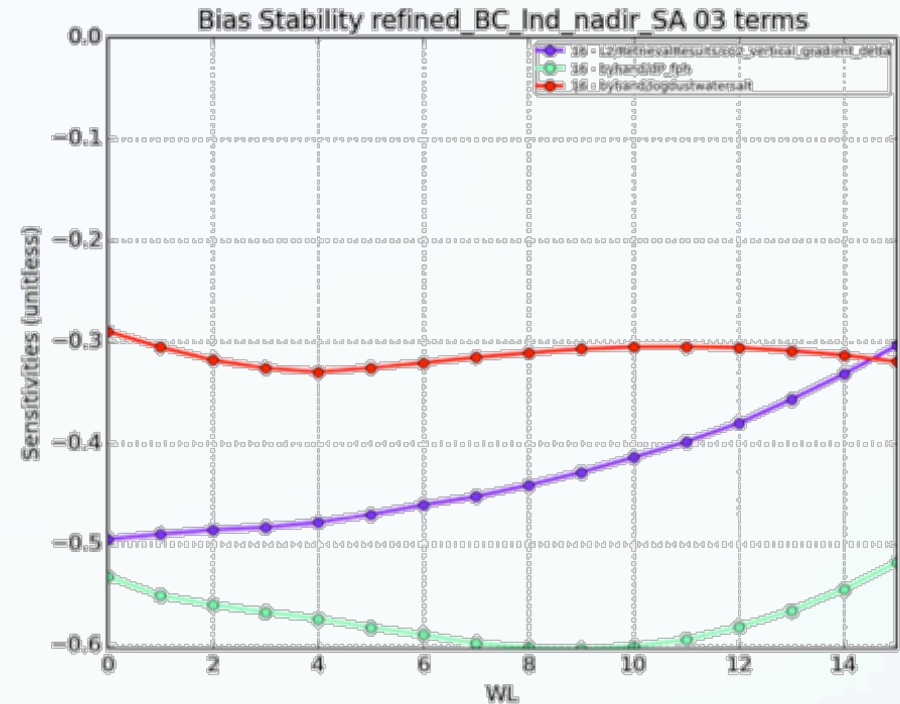
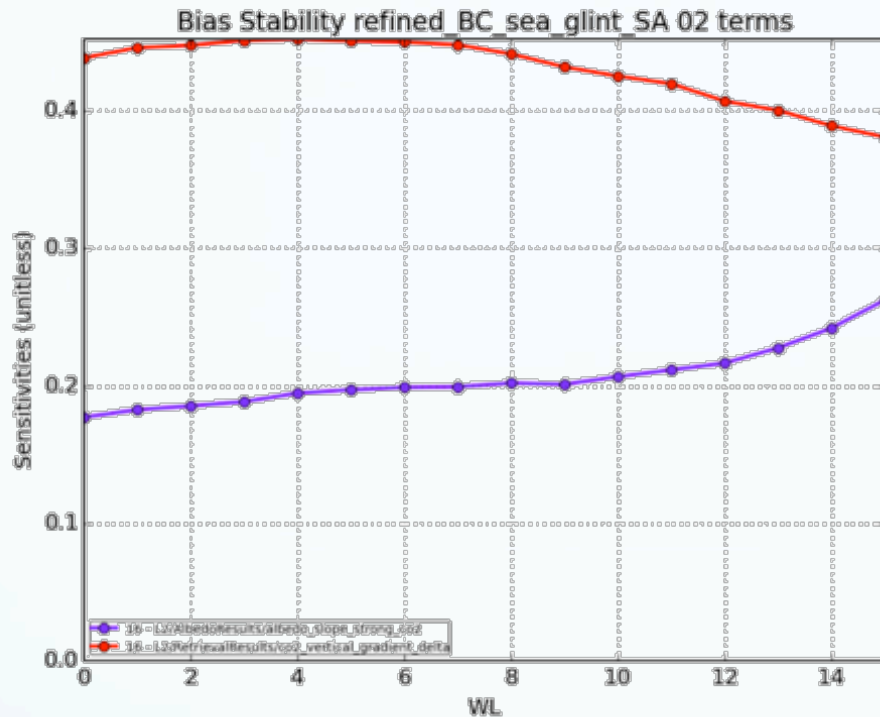


# Features WL's Use

**Bias-Corrected XCO2 vs. WL features**



# Bias & Filtration



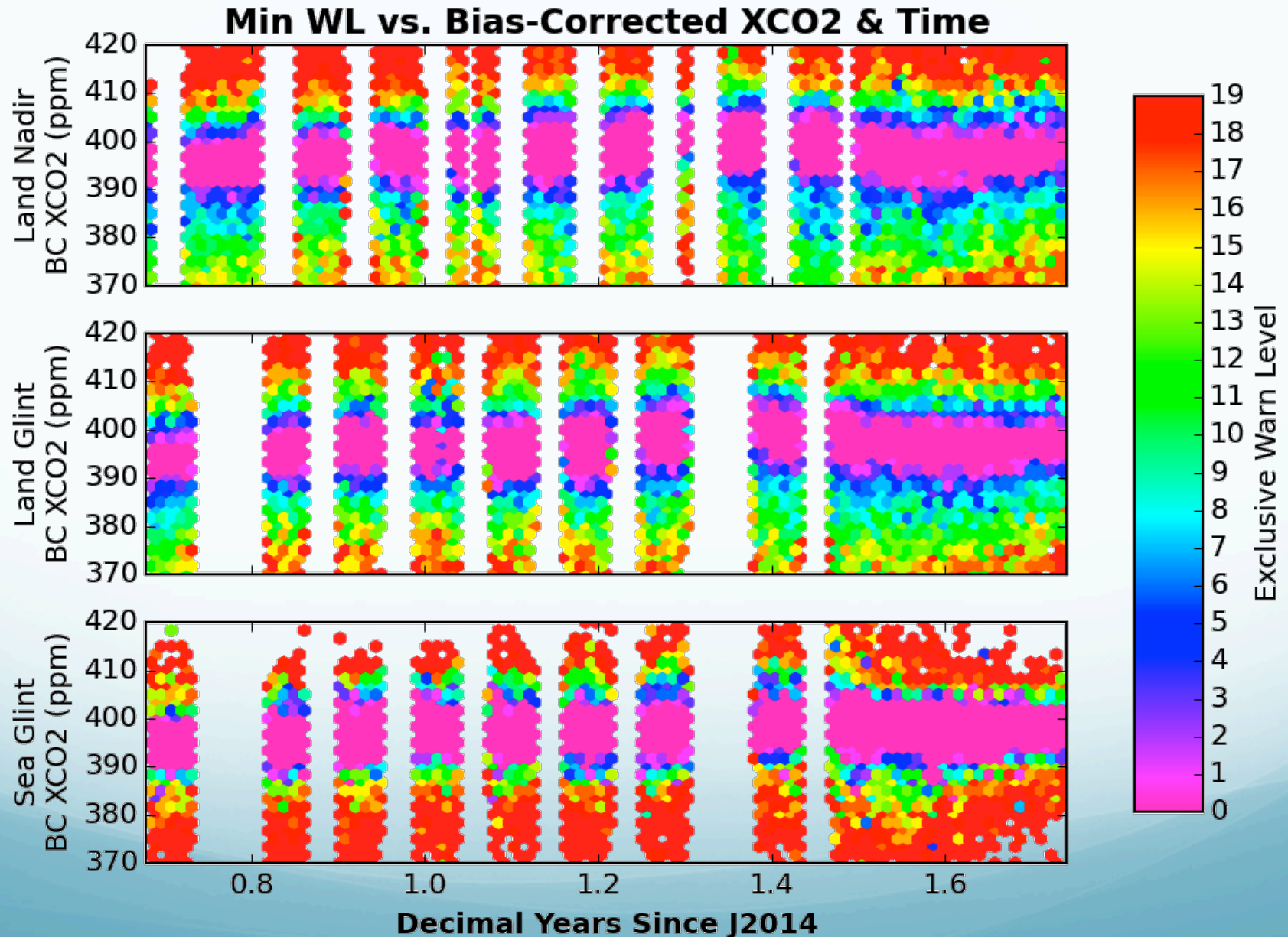
- Most XCO<sub>2</sub> derived quantities are function of Warn Level
- Must perform “sweep” of WL to look for stable regions
- XCO<sub>2</sub> bias is similarly sensitive
- For v7, bias was determined fixing WL ≤ 10 (middle of usage range)
- Some bias terms are insensitive to WL, others not so
- An excellent example of WL/filtration effects on science results

# Warn Level Summary

- WL's order OCO-2 data by level of confounding forces present
- Derived by reducing spurious  $\text{XCO}_2$  deviation in ~homogenous regions
- Sweeping WL's to look for (un)desirable traits makes custom filter
- Sweeping science results as function of WL tests robustness of claims
- Single parameter does “heavy lifting” of filtration definition
- Correlate with independent measures of retrieval quality (uncertainty)

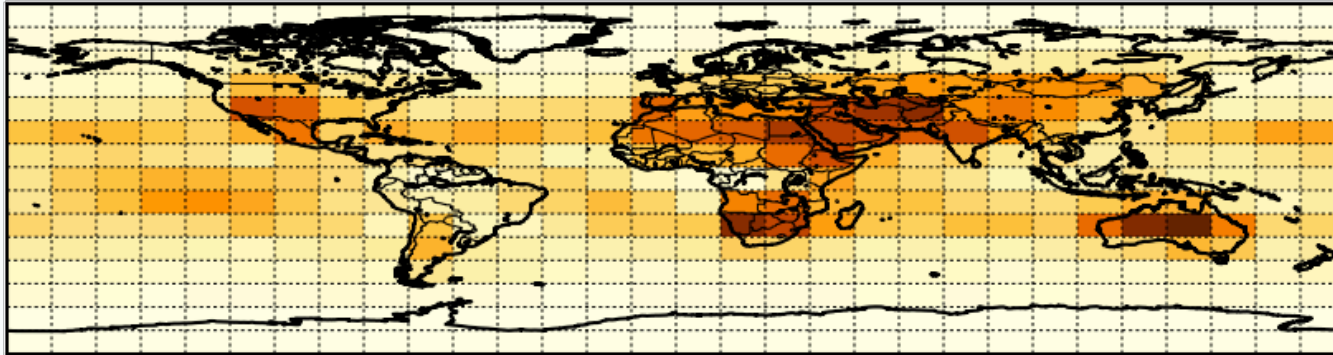
# Backup Slides

# Binned Temporal Coverage

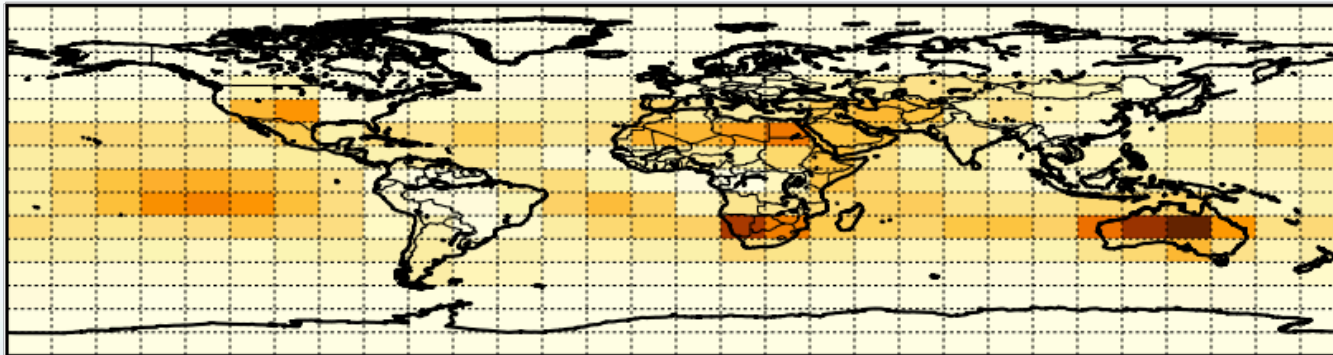


# Spatial Coverage

WL  $\leq$  19



WL  $\leq$  10



WL  $\leq$  5

